Correlated Polarons in the Paramagnetic Insulating Phase of $La_{0.7}Ca_{0.3}MnO_3$

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Electron-phonon coupling is the supplementary mechanism added to the double exchange interaction in order to describe the behavior of colossal magneto resistance (CMR) materials. This coupling results in the formation of localized electrons with an associated lattice distortion—or polarons—in the paramagnetic insulating phase of CMR materials. Since x-rays are particularly suited to measurements of lattice distortions, x-ray scattering from polarons can be used to learn about the role played by electron-phonon coupling in the CMR materials. In this abstract, we report x-ray scattering studies of polarons in $La_{0.7}Ca_{0.3}MnO_3$.

The $La_{0.7}Ca_{0.3}MnO_3$ single-crystal was grown by floating zone techniques at Rutgers University. The sample was determined to be fully twinned, with a (110)/(002)-oriented surface normal (in orthorhombic, *Pbnm*, notation). For simplicity, reflections are referenced using the (110) surface normal direction.

At temperatures above the metal-insulator transition temperature (~252 K), diffuse peaks with an ordering wavevector of (0.5 0 0)/(0 0.5 0)—such as those recently reported by Dai *et al.*[1] and Adams *et al.*[2] using neutron diffraction—were observed. As the sample was cooled through the transition temperature into the ferromagnetic metallic phase, the diffuse peaks were observed to decrease in intensity, as can be seen below in Figures 1 and 2. The correlation length along the orthorhombic *a* and *b* directions was determined by using fits to data measured along H and K, as a function of temperature. Above the transition temperature, the correlation length was observed to be independent of temperature and isotropic, with a magnitude of 1-2 lattice constants.

The short correlation length of the diffuse peaks suggests that the correlated polarons observed in the paramagnetic insulating phase of $La_{0.7}Ca_{0.3}MnO_3$ are actually bipolarons, and a bipolaron structure such as that of an orbital order domain in the CE-type phase is consistent with the magnitude of the wavevector. The collapse of these bipolarons as the sample is cooled through the metal-insulator transition can be attributed to the onset of ferromagnetic ordering, which overcomes the localization of the bipolarons caused by the electron-phonon coupling.

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References: [1]P. Dai, J.A. Fernandez-Baca, N. Wakabayashi, E.W. Plummer, Y. Tomioka, and Y. Tokura, Phys. Rev. Lett. **85**, 2553 (2000). [2]C.P. Adams, J.W. Lynn, Y.M. Mukovskii, A.A. Arsenov, and D.A. Shulyatev, cond-mat/0009132.

$La_{0.7}Ca_{0.3}MnO_3$

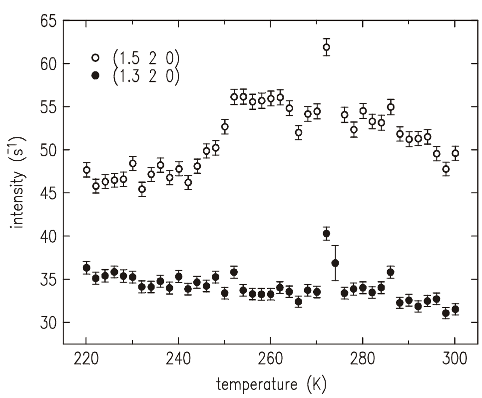

Figure 1. Scattering intensity at (1.5 2 0) (o) and (1.3 2 0) (●) as a function of temperature.

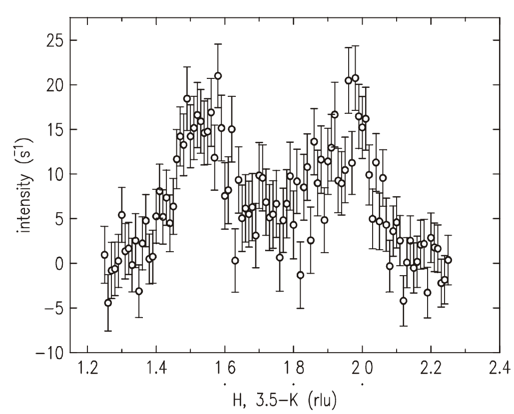

Figure 2. Transverse scan measured at 220 K subtracted from identical scan measured at 260 K.